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EFFECT OF SOIL SALINITY, SOURCES OF PHOSPHORUS AND BIOFERTILIZERS ON YIELD, NUTRIENT CONTENT AND UPTAKE IN COWPEA (*VIGNA UNGUICULATA* L.)

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Original Article

ABSTRACT

A pot experiment was conducted in 2015 at S.K.N. College of Agriculture, Jobner during kharif season using cowpea as a test crop to investigate the effect of phosphorus management in cowpea (Vigna unguiculata L.) grown on saline soils. Three levels each of saline soils (EC 1, 4.0 and 6.0 dS/m), phosphorus sources (SSP, DAP and PROM), and biofertilizers (control, PSB and PSB + VAM), were tested in completely randomized design with three replications. The results indicated that application of soil salinity having EC 1dS/m recorded the maximum yield, phosphorus and potassium content and uptake and nitrogen uptake of cowpea over rest of the treatments. But in case of nitrogen content lowest at EC 1dS/m. Result further indicate that application of phosphorus source PROM recorded the maximum and significantly higher yield, nitrogen, phosphorus and potassium content and uptake of cowpea over rest of the treatments. However dual inoculation with PSB + VAM recorded the maximum and significantly higher significantly higher yield, nitrogen, phosphorus and potassium content and uptake of cowpea over rest of the treatments. Between treatments the application of EC 1dS/m + PROM + Biofertilizer (PSB+VAM) proved superior in all these parameters over other treatments.

KEYWORDS: Biofertilizers, Cowpea, Phosphorus, Salinity, Uptake, PSB & VAM

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INTRODUCTION

Cowpea [*Vigna unguiculata (*L.) Wilczek] commonly known in India as lobia is one of the important *kharif* pulse crops grown for vegetable, grain, forage and green manuring. This crop has great importance because of availability of short duration, high yielding and quick growing variety. Green tender pods are used as vegetable; the vegetable cowpea pods contain moisture 84.6%, protein 4.3%, carbohydrate 8.0% and fat 0.2%. In many parts of arid and semi-arid regions, groundwater, which is often of poor quality is used as a major source of irrigation. The continuous use of such water for irrigation creates salinity or sodicity in soil. The problem is aggravated in the areas where saline / sodic ground water is used as a chief source of irrigation owing to a shortage of good quality water. Salt affected soils cover an area of nearly 13.8 Mha in the country (Yadav *et al.* 2007) and 1.24 M ha in Rajasthan and occurs to a greater or lesser extent in practically all the district of state (Sharma *et al.*, 2004). Unscientific and indiscriminate usages of saline water for irrigation causes an accumulation of soluble salts in the root zone and adversely affect the physical and chemical properties of irrigated soils which in turn decrease crop productivity due to reduced water availability to plants (Chauhan *et al*., 1988). Plant growth is either depressed or

entirely prevented due to excessive build-up of salinity in soil due to irrigation with saline water. Phosphorus is most indispensable mineral nutrient for pulse crop. Response of crops to phosphorus application on sodic soils has been reported by several workers (Yadav *et al.* 2009). Phosphorus is an important nutrient next to nitrogen. Its deficiency is the most important single factor, which is responsible for poor yield of couple on all types' soils. It is a constituent of nucleic acids as ribonucleic acid (RNA) and deoxyribonucleic acid (DNA), ADP and ATP nucleoprotein, amino acids, proteins, phosphatides, phytin, several co-enzymes viz., thiamine, pyrophosphate and pyrodoxyl phosphate.

VAM can play an important role in enhancing phosphorus availability to plant in P deficient soils. VAM fungi can save P-fertilizer by 25-30%. It is well known that VAM fungi improve plant growth through increased uptake of relatively immobile nutrients such as P, Zn, Cu etc. (Tarafdar and Rao, 1997). The inoculation of seeds with PSB culture increases the green pod yield over uninoculated control (Vaisya *et al.,* 1983). The phosphate solubilizing bacteria are aerobic and heterotrophic in nature. Under favorable conditions, they can solubilize 20-30% of insoluble phosphate and may increase the yield of crops by 10-30 % (Tilak and Annapurna, 1993). An attempt was therefore made to test the phosphorus management of cowpea under different levels that are soil salinity, sources of P and biofertilizers to explore the effect of phosphorus management on yield and nutrient management of cowpea grown on saline soils.

MATERIALS AND METHODS

A pot experiment was conducted at cage house of Department of Plant Physiology, College of Agriculture, Jobner during 2015 in completely randomized design (CRD) with three replications. The soil was loamy sand in texture, to attain the ECe level of 4 and 6 dS/m Cl^- and SO_4^{-2} of Na, Ca and Mg were added as solution keeping the ratio of 3:1 of Cl: SO_4 and thoroughly mix in the soil before seeding(Table 1), alkaline in reaction (pH 8.40), low in organic carbon (1.85 g/kg), and available nitrogen (128.10 kg/ha), medium in available phosphorus (20.25 kg P2O5/ha) and potassium (145.80 kg K2O/ha) content. Bulk density, particle density, Na, Ca, Mg, CEC, exchangeable Na and ESP (1.50 Mg/m^3, 2.60 Mg/m^3, 9.60 me/L, 1.2 me/L, 1.2 me/L, 6.8 cmol (P+) kg/soil, 0.65 cmol/kg and 9.55, respectively) of experimental soil. The experiment consisted of three levels of soil salinity (l, 4.0 and 6.0 dS/m), three sources of phosphorus (SSP, DAP and PROM), and three levels of biofertilizers (control, PSB and PSB + VAM) and thereby, making 27 treatment combinations.

Table 1: Amount of Different Salts and Their Ionic Composition Added in Base for Creating Different Salinities

EC (dS/m)	mmol/kg					Final ECe (dS/m)
	Na^+	Ca^{+2}	Mg^{+2}	Cl^-	SO_4^{-2}	
1 (base soil)	9.6	1.2	1.2	2.2	6.0	1.22
4.00	16.6	5.6	5.6	7.8	24.0	4.14
6.00	25.6	11.2	11.2	1.28	39.0	6.10

Soil was filled with cylindrical ceramic pots (20 cm diameter and 28 cm height). Each pot contained 10 kg of soil. At the time of filling the pots, the broken pieces of stone were placed in the bottom hole to allow free drainage. The cowpea cv. 'RC-19' was shown on 7^{th} July, 2015 with a seed rate of 5 seeds per pot. The crop was harvested on 15^{th} September, 2015. Fully mature and developed pods from randomly selected five plants from each plot was plucked and number of seeds were counted. The average number of pods and seeds per plants was worked out. After threshing and winnowing the weight of seeds in each pot was recorded in game per pot and then converted in to kg/ha.

RESULTS AND DISCUSSIONS

Effect of Soil Salinity

The grain and straw yield of cowpea decreased significantly with increasing levels of EC in soil. The soil salinity levels S_4 and S_6 significantly decreased the grain and straw yield over S_1. The decrease in the grain yield with the application of S_4 and S_6 was 9.82 and 37.82 per cent over (normal soil) S_1, respectively. The S_4 and S_6 decreased the straw yield to the extent of 9.81 and 37.81 per cent over S_1 (normal soil). The data given in Table 2 revealed that N content in grain tended to increase significantly with increasing levels of soil salinity. A similar trend of increase was also noticed in the straw. The maximum N content in grain was recorded under S_6, which was at par with S_4. The N content was significantly higher in grain by 10.11 percent over normal soil. The N content in straw significantly higher was 5.70 and 18.11 percent as compared to S_1 (normal soil). The increasing levels of soil salinity significantly decreased the N uptake by grain and straw. The S_4 and S_6 decreased the N uptake by grain to an extent of 3.40 and 30.82 per cent and in straw 2.85 and 30.61 per cent over control, respectively. The P and K content decreased significantly with increasing levels of soil salinity (table 3). The maximum reduction in P content in grain and straw was recorded under S_6 and it was lower by 20.87 and 28.66 in grain and 8.49 and 16.33 percent in straw over S_4 and S_1. In case of grain, the decrease in K content due to S_6 over S_1 and S_4 was to the extent of 12.48 and 4.66 per cent. Similarly, in straw, the corresponding values of decrease in K content were 16.80 and 7.63 per cent. The P and K uptake decreased significantly with increasing levels of soil salinity (table 3). The maximum reduction in P uptake in grain and straw was recorded under S_6 and it was lower by 28.56 and 55.60 in grain and 17.55 and 48.09 percent in straw over S_4 and S_1, respectively. The S_4 and S_6 decreased the K uptake by grain to the extent of 13.99 and 45.60 per cent and in straw by 16.72 and 41.53 per cent over normal soil, respectively. Pods per plant and grains per pod decreased with increase in level of soil salinity. In general, the significant decrease in yield under influence of different salinity levels was due to the increase in EC of soil, which in turn responsible for the reduction in grain and straw yield by causing a restricted availability of water and nutrients to the plant. Several workers have also observed the significant yield reduction by Khandelwal *et al.*, 1990, Netwal (2003) in cowpea and Jat (2011) in chickpea with the increasing level of soil salinity. The increase in grain yield under application of PROM might be due to an organic source of nutrition and organic matter and various essential nutrients. The beneficial effect of PROM addition is also related to the improvement in soil physical properties and soil health. These results were confirmed with the finding of Sharma *et al*. (2001) and Shekhawat and Sharma (2001). The observed additive influence of biofertilizers is attributed to mutually beneficial and the synergistic role played by each group of biofertilizers used. Such mutually beneficial synergistic effect has also been reported by Khatkar *et al*. (2007), Rathore *et al*. (2010) and Pramanik *et al.* (2012), Khan *et al*. (2015).

Effect of Sources of P

The application of different sources of phosphorus significantly increased the grain and straw yield of cowpea. PROM as a phosphorus source gave significantly higher (5.38 g/pot) grain yield as compared to SSP and DAP. The increase in grain yield was obtained due to PROM to the extent of 17.3 and 10.92 percent, respectively over DAP and SSP. The increase in straw yield with PROM was 9.92 and 31.33 per cent compared to DAP and SSP, respectively. The N, P and K content in grain and straw of cowpea at harvest increased significantly with the application of PROM as compared to DAP and SSP. Highest N content in grain and straw was recorded with the application PROM which was higher by 11.36 per cent in the case of grain, which was at par with DAP and 2.70 and 10.43 per cent in case of straw over DAP and

SSP, respectively (table 2). Application of PROM registered a significant increase of 46.19 and 69.01 percent in grain and 10.71 and 22.04 per cent in straw over DAP and SSP (table 3). Application of PROM indicates K content an increase of 1.81 and 15.22 percent in grain and 6.38 and 13.79 per cent in straw over DAP and SSP, respectively (table 3). The N, P and K uptake by grain and straw increased significantly with PROM as compared to DAP and SSP. An increase in N uptake in grain recorded was 15.37 and 63.97 per cent and in straw, 18.55 and 67.16 per cent over the DAP and SSP, respectively (table 2). The phosphorus uptake by grain and straw increased significantly with PROM by grain and straw due to application of PROM was recorded by 38.52 and 84.15 percent in grain and 32.01 and 80.00 per cent in straw over that of DAP and SSP, respectively (table 3). An increase in K uptake due to PROM application by grain and straw was recorded in 13.07 and 70.00 percent in grain and 18.08 and 49.38 per cent in straw over that DAP and SSP, respectively (table 3). The beneficial effect of PROM addition is also related to the improvement in soil physical properties and soil health. This might be due to the fact that excess assimilates stored in the leaves and later translated into grains at the time sensing being the closest sink. Thus, ultimately, increased the grain yield and straw yield was also increased due to the result of overall increased growth and development of plants. These results were confirmed with the finding of Sharma *et al*. (2001) and Shekhawat and Sharma (2001). The increase in N content might be due to well-developed root system which might have increased the availability of phosphorus to soil microbes which leads to increased multiplication of *Rhizobium* bacteria and which in turn resulted in increased atmospheric N2-fixation by better utilization of soil nitrogen (Tandan, 1991). The increased availability of P status in soil increased the nutrient content, both macro and micro with P fertilization could be attributed to the balanced nutrient status of soil which was deficient in N and P and medium in K. The greater availability of improved the plant root system which resulted in greater K accumulation in the crop. These results were also reported by Basak and Subodh (2002), Hemaletha *et al.* (2002) and Kumar *et al.* (2002).

Effect of Biofertilizers

The dual inoculation with PSB + VAM registered significantly higher grain and straw yield of cowpea over grain inoculation with PSB alone and no inoculation (table 2). PSB + VAM showed an increase of 16.10 and 48.91 percent in grain yield over PSB alone and no inoculation. In case of straw yield represent an increase of 16.20 and 48.92 per cent over PSB and no inoculation, respectively. The application of biofertilizers PSB + VAM inoculation recorded significantly higher N content in grain and straw over PSB alone and no inoculation and represented an increase of 11.43 per cent in grain, which was at par with PSB and 2.21 and 8.51 per cent in straw, respectively over PSB alone and no inoculation (table 2). The inoculation of grain with PSB+VAM registered significantly higher phosphorus content in grain and straw and noted an increase of 19.33 and 44.96 in grain and 13.66 and 26.40 in straw, respectively over PSB alone and no inoculation (table 3). Inoculation with PSB +VAM registered significantly higher K content in grain and straw noted an increase of 5.58 and 14.08 in grain and 5.83 and 12.09 per cent in straw (table 3), respectively over PSB alone and no inoculation. The grain inoculated with PSB and soil inoculated with VAM (PSB + VAM) noted significantly higher N, P and K uptake by grain over PSB and no inoculation, In case of N uptake representing an increase of 20.61 and 65.93 per cent and in straw 23.34 and 67.14 per cent over PSB and no inoculation, respectively (table 2). P uptake representing an increase of 38.53 and 84.18 percent in grain and 32.01 and 88.13 per cent in straw over PSB alone and no inoculation (table 3). The grain inoculated with PSB and soil inoculated with VAM (PSB + VAM) noted significantly higher K uptake by grain and straw over PSB and no inoculation, representing an increase of 22.56 and 69.86 percent in grain and in straw 22.86 and 49.50 per cent in straw over PSB and no inoculation (table 3). Increase in grain and straw yield due to inoculation of PSB+VAM may be attributed to its phosphate solubilizing effect. PSB solubilize insoluble fixed P in soil by

production of organic acids in solubilizing minerals and phosphorylated minerals is attributed to the lowering of soil pH, which helps in the release of phosphorus from the stable complexes with cations such as Ca^{2+}, Mg^{2+}. Such reaction also prevents the fixation of phosphate ions. The results obtained in the present investigation are in line with the findings of Singh *et al*. (2012) and Khan *et al*. (2015). The observed additive influence of biofertilizers is attributed to mutually beneficial and the synergistic role played by each group of biofertilizers used. Such mutually beneficial synergistic effect has also been reported by Pramanik *et al.* (2012). It could be attributed to better root growth due to increased availability of P by PSB + VAM besides secretion of growth promoting substances (Totawat *et al*., 2000). VAM increased nutrient uptake through a reduction of the distance that nutrients must diffused to plant roots by accelerating the rate of nutrient absorption and nutrient concentration at the absorption surface (Bowen *et al*., 1975) and finally be chemically modifying the availability of nutrients for uptake by plants through mycorrhizal hyphae by Monaliza *et al.* (2013).

CONCLUSIONS

On the basis of one year field experimentation, it seems quite logical to conclude that grain and straw yield increased and improve nutrient content and uptake with application of phosphorus source PROM and seed inoculation with PSB and VAM. However, higher levels of soil salinity adversely affect the yield, nutrient content and uptake of cowpea.

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APPENDICES

Table 2: Effect of Soil Salinity, Sources of P and Biofertilizers on Grain and Straw Yield, N Content and Uptake by Grain and Straw of Cowpea

Treatments	Grain Yield (g/pot)	Straw Yield (g/pot)	N Content (%) Grain	Straw	N Uptake (mg/pot) Grain	Straw
Soil Salinity						
S_1 (*1 dS/m)	5.50	8.25	3.048	1.076	169.943	65.069
S_4 (4 dS/m)	4.96	7.44	3.263	1.238	164.150	62.210
S_6 (6 dS/m)	3.42	5.13	3.391	1.314	117.568	45.146
S. Em. ±	0.06	0.09	0.056	0.20	3.214	1.285
C. D. (P=0.05)	0.18	0.24	0.158	0.57	9.085	3.632
Sources of P						
P_1 (SSP)	3.65	5.49	3.045	1.102	111.074	42.243
P_2 (DAP)	4.85	7.26	3.245	1.185	158.137	59.565
P_3(PROM)	5.38	8.06	3.391	1.217	182.450	70.617
S. Em. ±	0.06	0.09	0.056	0.020	3.214	1.285
C. D. (P=0.05)	0.18	0.24	0.158	0.057	9.085	3.632
Biofertilizers						
B_0(Control)	3.68	5.52	3.044	1.104	111.933	42.820
B_1(PSB)	4.72	7.08	3.265	1.720	153.989	58.035
B_2(PSB+VAM)	5.48	8.22	3.392	1.198	185.739	71.570
S. Em. ±	0.06	0.09	0.056	0.020	3.214	1.285
C. D. (P=0.05)	0.18	0.24	0.158	0.057	9.085	3.632

Table 3: Effect of Soil Salinity, Sources of P and Biofertilizers on P and K Content and Uptake by Grain and Straw of Cowpea

Treatments	P Content (%) Grain	Straw	P Uptake (mg/pot) Grain	Straw	K Content (%) Grain	Straw	K Uptake (mg/pot) Grain	Straw
Soil salinity								
S_1 (*1 dS/m)	0.436	0.153	25.302	13.017	0.793	1.755	44.388	147.103
S_4 (4 dS/m)	0.345	0.140	18.074	10.732	0.756	1.621	38.174	122.499
S_6 (6 dS/m)	0.311	0.128	11.237	6.756	0.694	1.460	24.145	86.011
S. Em. ±	0.007	0.003	0.696	0.323	0.012	0.016	0.925	2.030
C. D. (P=0.05)	0.019	0.008	1.966	0.913	0.034	0.045	2.615	5.740
Sources of P								
P_1 (SSP)	0.284	0.127	10.863	7.146	0.683	1.508	25.387	94.603
P_2 (DAP)	0.328	0.140	16.651	10.487	0.773	1.613	38.165	119.683
P_3(PROM)	0.480	0.155	27.099	12.872	0.787	1.716	43.154	141.327
S. Em. ±	0.007	0.003	0.696	0.323	0.012	0.016	0.925	2.030
C. D. (P=0.05)	0.019	0.008	1.966	0.913	0.034	0.045	2.615	5.740
Biofertilizers								
B_0(Control)	0.298	0.125	11.578	7.080	0.696	1.521	26.124	95.807
B_1(PSB)	0.362	0.139	18.040	10.098	0.752	1.611	36.203	116.569
B_2(PSB+VAM)	0.432	0.158	24.995	13.326	0.794	1.705	44.379	143.236
S. Em. ±	0.007	0.003	0.696	0.323	0.012	0.016	0.925	2.030
C. D. (P=0.05)	0.019	0.008	1.966	0.913	0.034	0.045	2.615	5.740